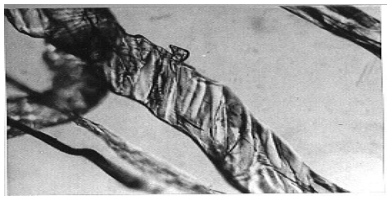
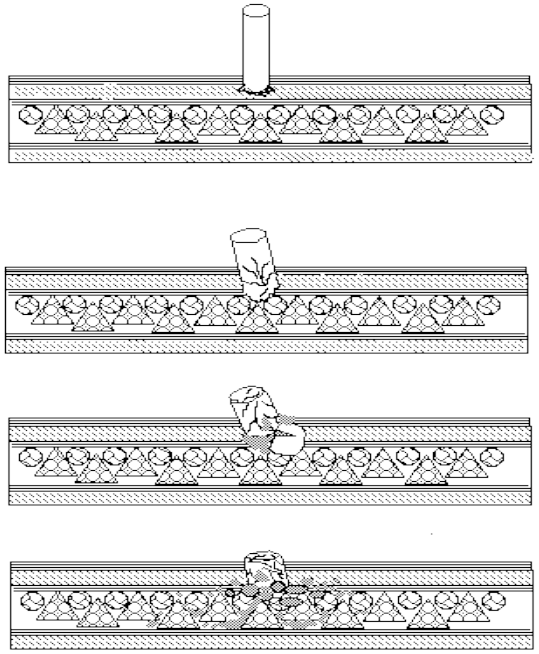
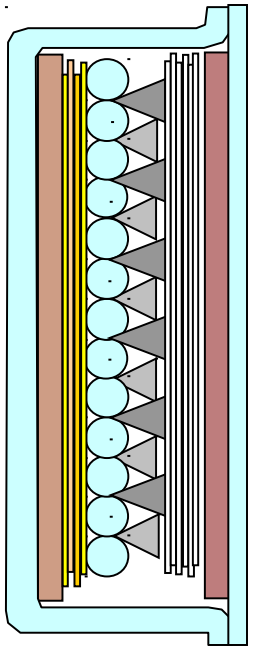
Non-Woven "Felt Armor" Fabrics for Enhancing Fragmentation Protection







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SES *Science & Engineering Services Inc.*

PLAINSMAN BALLISTIC ARMOR PROTECTIVE ARMOR INTERNATIONAL

Non-Woven "Felt Armor" Fabrics for Enhancing Fragmentation Protection

SESI is an established, full-capabilities company serving both Government and commercial customers from basic science to rapid prototyping to production.

Established in 1988 – $53M in 2003 (10% R&D) – 150 people

<u>Outline of presentation:</u>

- **ArmorFelt**
  - **What is it?**
  - **How does it perform?**
  - **Why is it better?**
  - **Where is it going?**
  - **What is possible?**
- **Preliminary look at applying Chaos Theory to Vehicle Armor**
- **Closing Thoughts**

Non-Woven "Felt Armor" Fabrics for Enhancing Fragmentation Protection

Science & Engineering Services Inc. (SESI) has partnered with Plainsman Armor International (PAI) to Develop…

- **ArmorFelt –**
  - **NonWoven Ballistic Fabric**
  - **Equivalent Ballistic Protection at Lighter Weight**
- **Chaotech**
  - **Chaos Theory Based Vehicle Armor**
  - **Superior Protection at Lighter Weight and Cost**

ArmorFelt- What is it?

- **A soft, air permeable, ballistic felt using Nonwoven Fabric technology formed in a proprietary way**

- **Consists of**
  - **Semi-ThermoPlastics – Aramids Like Kevlar and Twaron**
  - **ThermoPlastics – Polyethylenes Like Spectra and Dyneema**

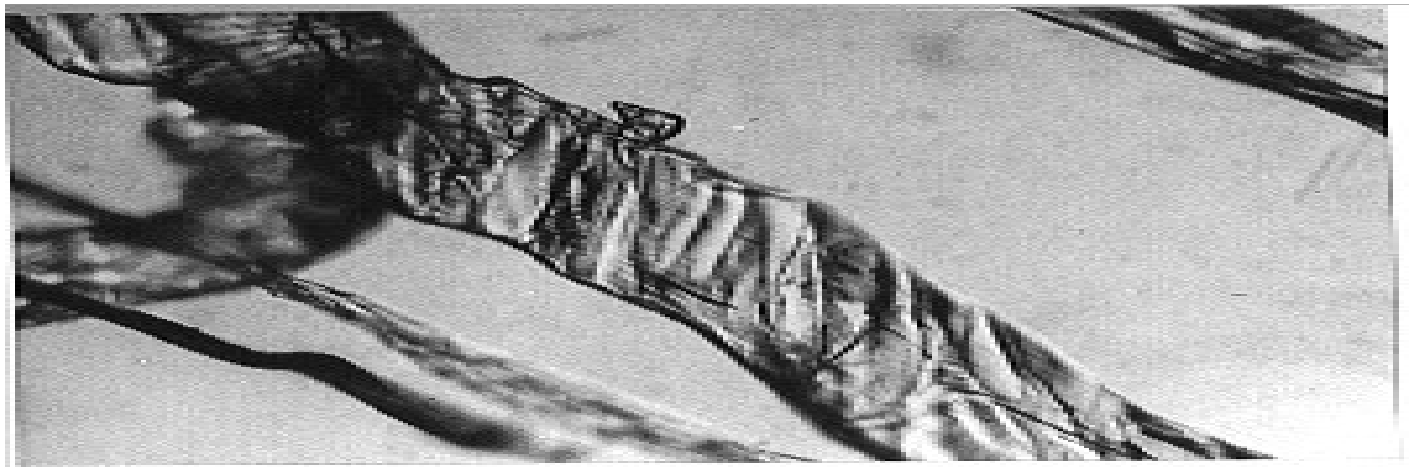
- **Combines materials and forming processes so that when a projectile strikes the material:**

- **Strain Energy is radiated beyond the impact area**

- **Network Integrity is preserved by the non-malleability of the material itself**

BEST USE IS TEAMED WITH TRADITIONAL WOVEN BALLISTIC FABRICS LIKE KEVLAR AND TWARON

ArmorFelt – Why is it better?



ArmorFelt helps to better dissipate projectile and fragment energy through three mechanisms:

- **Fibrillation of the polyaramid fibers.**
- **Thermoplastic deformation of the polyethylene fibers.**
- **Projectile and fragment path “chaos” by the felt non-pattern polyaramid + polyethylene fibers.**

ArmorFelt Applications

Evacuation blankets, drapes

Photo: http://www.galls.com

Body armor

Vehicles, shelters and barracks

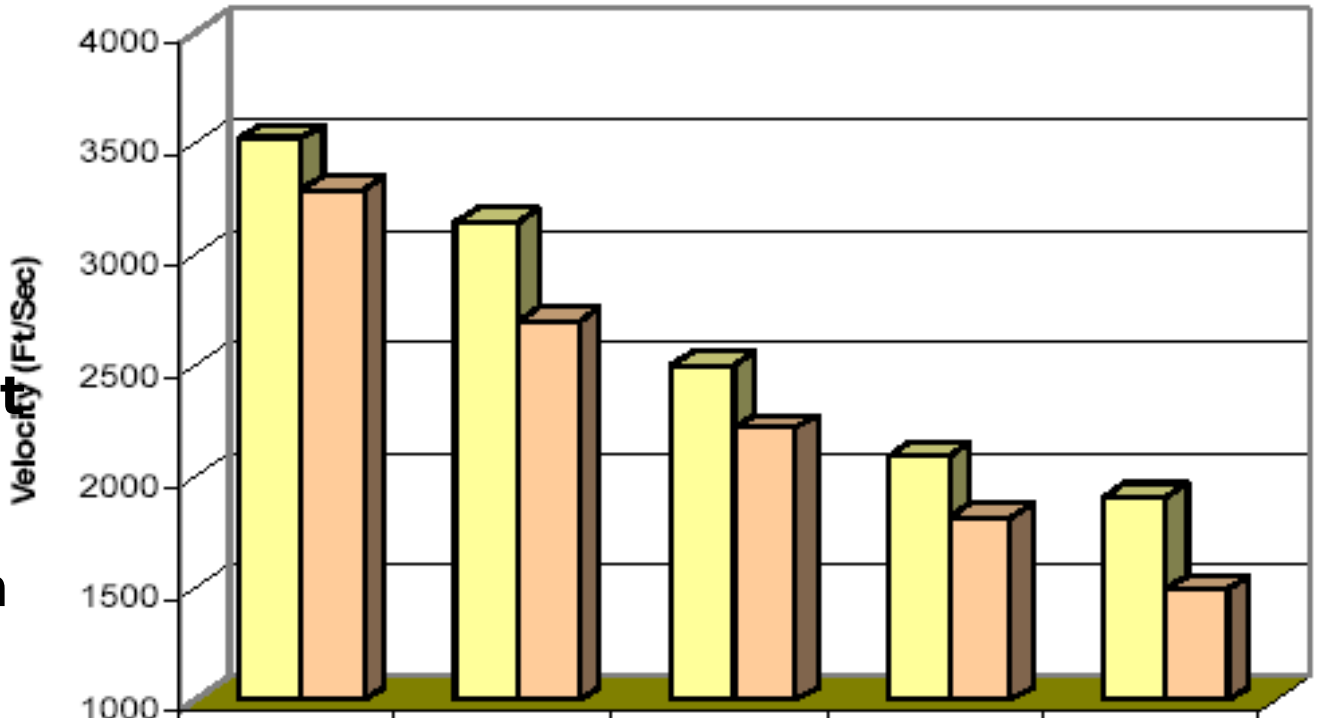
Aircrew and aircraft

Photos: http://www.army.mil

"THIS PRODUCT WILL SAVE SOLDIER LIVES AND IT WILL SAVE THE MILITARY LOTS OF MONEY--IE --IT IS LIGHTER, COSTS LESS AND HAS BETTER BALLISTIC CHARACTERISTICS." GEN (R) Tom Schwartz

Testing Results in 2003 At Aberdeen Proving Grounds

- **ArmorFelt Air Warrior Vest**
- **Exceeded Current Vest by 7-27% @ 7% Less Weight with More Flexibility**



	2 grain	4 grain	16 grain	64 grain	9 mm
Plainsman	3525	3152	2505	2100	1910
Specification	3300	2700	2225	1825	1500

Fragmentation **Projectile**

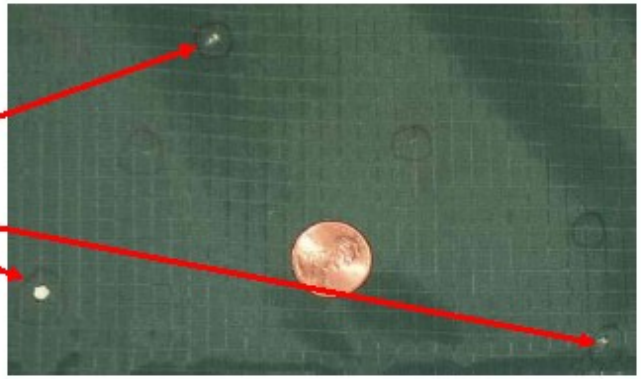
ArmorFelt – How does it perform?

US Marines Test Results
Hand Grenades

- Tests performed at Quantico, VA
- 2 samples tested
  - A) Identical to Air Warrior
  - B) Heavier than Air Warrior
- M-67 hand grenade
  - One detonation each target from 4 feet range
- Results
  - A) No penetrations on Air Warrior type
    - 22 hits by fragments
  - B) 1 penetration on heavier type
    - 17 hits by fragments

(top)

(bottom)



November 2003

ArmorFelt – How does it perform?

US Marines Test Results
I.E.D.'s

2.2lbs/ft^2 sample, range **15 meters**

- **Nine fragments impacted the sample panel**
  - No complete penetration.
  - 3 large (50-150 grain) fragments impacted the panel along with six smaller (50 grain or less) fragments.
- **One of the large fragments, penetrated three ArmorFelt and 14 aramid layers**
  - (out of 3 layers of ArmorFelt, 40 layers of Kevlar, 3 layers of ArmorFelt)
- **No other large fragments, penetrated deeper than three ArmorFelt layers**
- **None of the fragments completely penetrated the armor.**

2 December 2003

ArmorFelt – How does it perform?

US Marines Test Results
I.E.D.'s (cont)

2.2lbs/ft^2 sample, range **5 meters**

- **22 fragments impacted the sample panel**
  - 1 complete penetration.
  - 2 large (50-150 grain) fragments impacted the panel along with twenty smaller (50 grain or less) fragments.
- **Only one of the two large fragments, completely penetrated the armor**
  - (3 layers of ArmorFelt, 40 layers of Kevlar, 3 layers of ArmorFelt)
- **None of the smaller fragments penetrated the armor.**

2 December 2003

ArmorFelt – Where is it going?

At the request of Air Warrior and based on 2003 testing at Aberdeen Proving Ground, we are developing improvements to Air Warrior soft body armor…

Our goals are to enhance performance for:

1. **Further reductions in weight**
2. **Further improvements in flexibility**
3. **Improvement in air permeability (breathability)**
4. **Equivalent or improved ballistic resistance to the existing soft body armor (threats as specified by the US Army Air Warrior program specification)**

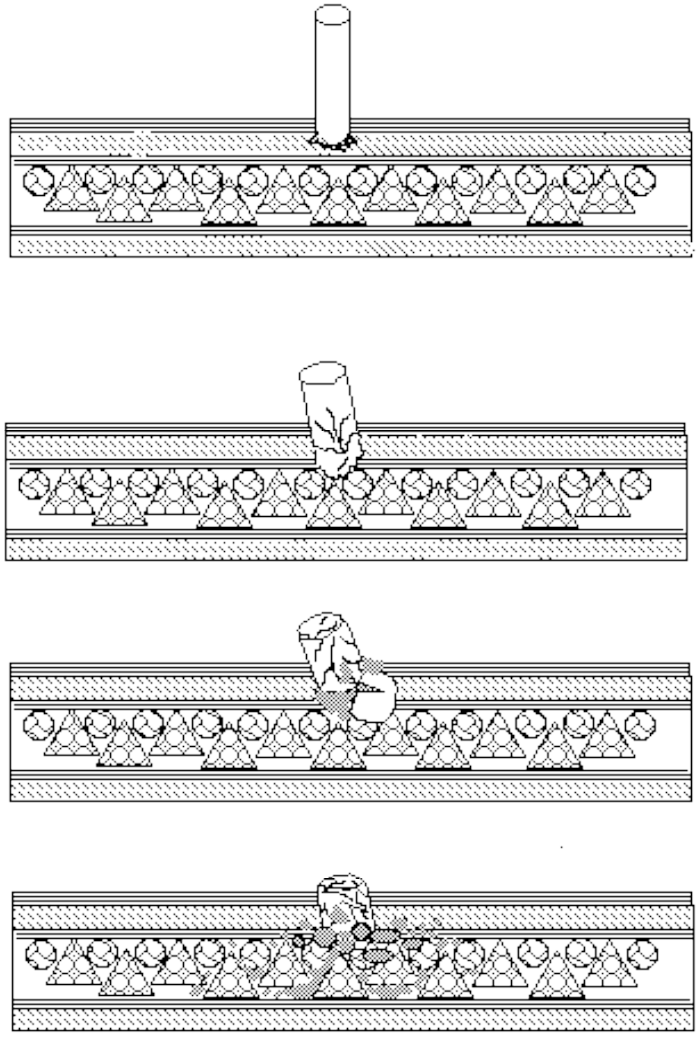
Period of performance: March 2004 to December 2004

ChaoTech – Applying Chaos Theory-Based Solutions to Defeat AP Munitions

If…A bullet trajectory is a highly ordered kinetic path and targets are destroyed by release of the kinetic energy in that projectile path…

Then…Destabilization of that path can result in enhanced energy bleed from the projectile with reduced lethality and kinetic energy transfer to the intended target…

- **Multiple, viable simultaneous projectile paths**
- **Projectile fragmentation and separation by internal geometry**



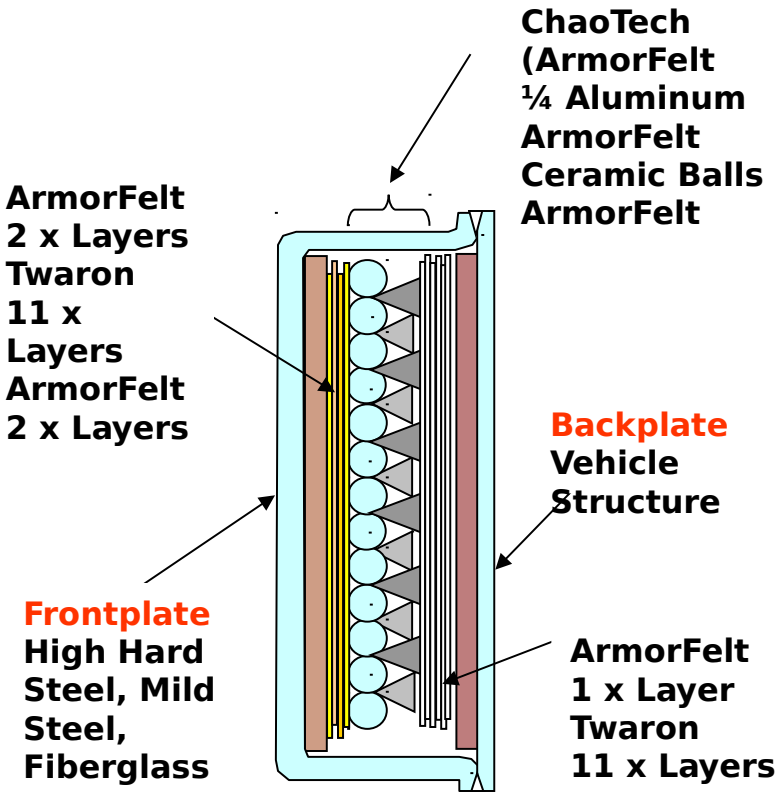
Improved Ballistic Protection Technology

Combined Technologies for Up-armoring enhancements:

Designed to Meet Threats:

7.62mm AP @ 2,887 fps
And
20mm FSP@ 3,500 fps

Key is for Front Plate to be light enough to strip off AP Jacket to allow ArmorFelt and ChaoTech to Stop projectile with NO backplate deformation



ChaoTech Construct

Improved Ballistic Protection Technology

Preliminary Results of Performance During Company IR&D Testing:

• 5 Separate Shots and one Grouping of 3 of
7.62mm AP @ 2709-2782 fps

→ No Penetration of ChaoTech with a 3/8" HHS Front Plate at a weight of 40 lbs/ft2 (OVERKILL)

• 7.62mm AP @ 2745 fps with a fiberglass front plate

→ No penetration of ChaoTech at a weight of 10.64 lbs/ft2

Improved Ballistic Protection Technology

Path Forward:

- **Optimize Titanium-based ChaoTech materials with those of lower cost, such as…**
  - **Boron Carbide**
  - **Silicon Carbide**

- **Work to Lighten Front Plate to Absolute Minimum**

- **Work to Optimize ArmorFelt Layers**

- **Continue Modeling and Simulation to optimize up-armoring Design and Weight**

ArmorFelt – Closing Thoughts

ArmorFelt is made of the some of same basic constituents as other Armor materials…

When ArmorFelt is combined with other materials in a layered construct, the data suggests that ballistic properties improve.

ArmorFelt is competitively priced and commercially available in
60-inch rolls based on required armor protection capabilities.

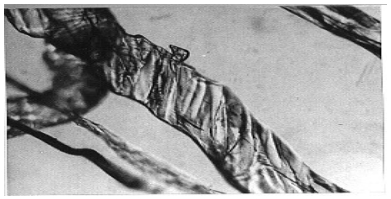
Blending ArmorFelt with Chaos Theory may offer the potential for some unique up-armoring solutions.

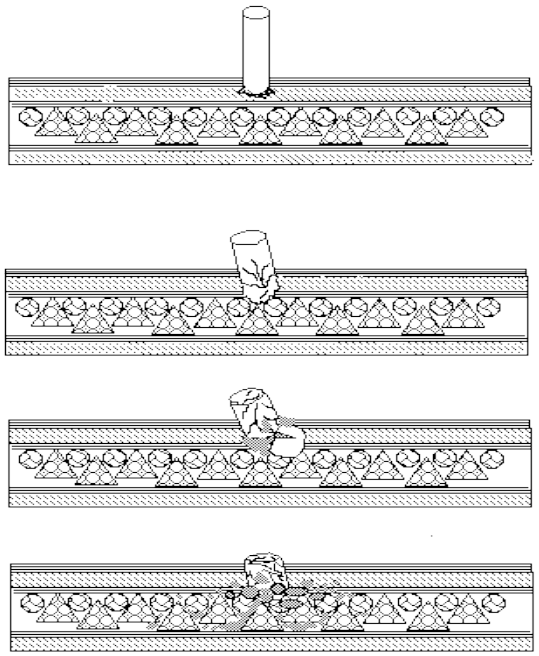
We'd welcome the opportunity to partner for supporting our Warfighters.

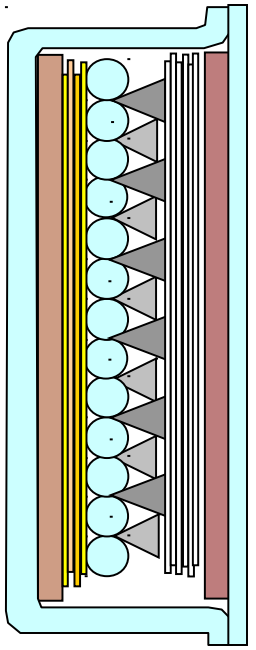
Ultimately, we're limited only by our drive and creativity to solve tough problems.

Science & Engineering Services Inc.

ArmorFelt – Our Team







Our Team: Dr. Howard Thomas, Mr. Richard (Doc) Savage,

Dr. Bob Serino, & Mr. Carl Runyon

We gratefully acknowledge key financial suppor from PM, Air Warrior

SES Science & Engineering Services Inc.

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